POLLUTION CONTROL GUIDELINES

FOR

MUNICIPAL EFFLUENT APPLICATION TO LAND

BC
Province of
British Columbia
Ministry of
Environment

Jan. 1983

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Jan. 1983

CANADIAN CATALOGUING IN PUBLICATION DATA

Spencer, J.G. (John Gordon), 1926-
Pollution control guidelines for municipal effluent application to land.

Bibliography: p.
ISBN O-7719-8499-5

1. Sewage irrigation — Standards — British Columbia. 2. Sewage disposal in the ground — Standards — British Columbia. I. Oldham, W. K. II. Schulz, E. (Erich), 1941- III. British Columbia. Ministry of Environment. IV. Title.

TD760.S64 628.3'623'09711 C81-092085-9

1st edition Jan. 1981
2nd edition Jan. 1983

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1. PREFACE

In order to determine what steps are necessary in the Province to control pollution, various 'objectives' have been published by the Pollution Control Board. The 'objectives' state that for municipal wastes various guidelines are necessary including one for the discharge of effluent to land. The reason for this is that additional criteria had to be defined to establish acceptable practices for land disposal without pollution or degradation of the land, surface water or ground water. With good design and management land disposal can go beyond pollution control and abatement becoming a natural recycling process. Waste becomes resource. Accordingly, a Committee to examine the matter was thereafter struck consisting of

Mr. J.G. Spencer, P. Eng., Chairman
Ministry of Environment

Dr. W.K. Oldham, P. Eng.
University of British Columbia

Mr. E. Schulz, C.E.T.
Ministry of Agriculture and Food

They have worked in close cooperation with the Ministry of Health, Ministry of Agriculture and Food and others in drafting the guidelines which follow and their assistance is gratefully acknowledged.

The guidelines are intended for those seeking permits under the Pollution Control Act to construct and/or operate surface and subsurface land application systems for treated municipal type wastewaters and are for use in conjunction with the "Pollution Control Objectives for Municipal Type Waste Discharges in British Columbia." They will be used in the assessment of applications. Each application is assessed on its merits and while the responsibility of the design engineer is not to be diminished, the word "shall" and the like in the text generally indicate practices which are acceptable. However it should be noted that, while limiting values are shown for various design and operating parameters, it is generally intended that flexibility be allowed where sufficient technical data is supplied by the applicant to substantiate variance.

The disposal methodologies in the guidelines are limited to those that are considered to have an implementation potential in British Columbia. If another type of land disposal is considered, design and operating procedures will necessarily have to be decided on the basis of site-specific investigations.

A glossary of terms is given in Section 2. The first time a word or term appears in the text that is defined in the Glossary, it is capitalized.

R.H. Ferguson, P. Eng.
Director
Waste Management Branch

2. GLOSSARY

Afforestation — the establishment of forest cover on areas not normally forested by seeding or planting.

Agriculture — the science and art of cultivating the soil, producing crops and raising livestock.

Agrologist — a specialist in that branch of agriculture dealing with soils especially in relation to crops.

Algae — aquatic nonvascular plants with chlorophyll often masked by a brown or red pigment.

Application Efficiency — the ratio of net volume of desired application to the gross volume of water delivered by the irrigation system.

Aquaculture — the science and art of cultivating water loving plants.

Aquifer — any soil/rock formation that has sufficient porosity and water yielding ability to permit the extraction/injection of water at reasonably useful rates.

Availability Coefficient — the fraction of the available water storage capacity over which water is readily available for plant use.

AWSC — Available Water Storage Capacity of the soil is the amount of water stored between field capacity and the permanent wilting point.

Bacteria (pl. of bacterium) — unicellular, plant-like microorganisms, lacking chlorophyll; saprophytic, parasitic, or pathogenic.

BOD_5 — an empirical laboratory test to determine Biochemical Oxygen Demand of wastewaters at 5 days: the quantity of dissolved oxygen required by microorganisms while stabilizing biodegradable organic matter in a sample over a five day period at 20°C in the absence of light.

Buffer Zone — the distance between the boundary of an irrigated property and the periphery of the area designed to be wetted by impact of the sprayed liquid.

Clay — mineral particles less than 0.0020 mm in diameter.

Coliforms — all of the aerobic and facultative anaerobic, gramnegative, non-spor-forming, rod shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C — are the indicator bacteria for fecal contamination.

Disinfection — the destroying of microorganisms generally by chlorination or equivalent method.

Effective Rooting Depth — that depth in the soil above which roots obtain 90% or more of their water requirements.

Effective Size — D_{10} — soil particle diameter of which 10 per cent of material by weight is finer.

Eutrophication — the process of enrichment of a body of water with nutrients and with a subsequent increase in biomass resulting in a seasonal depletion of oxygen.

Evaporation — loss of water from a bare soil or free water surface by change of phase from liquid to vapor.

Evapotranspiration — the total loss of water from the soil by evaporation and by transpiration from the plants growing thereon.

Fecal — relating to feces — bodily waste discharged through the anus.

Field Capacity — the maximum amount of capillary water that can be held in a freely drained root zone.

Filtration — removal of solids from water by passing through a filter.

Frost Free Period — the period between the last spring frost (0°C, 32°F) and the first autumn frost (0°C, 32°F).

Growing Season — the period between the dates on which the mean temperature of 5.0°C, 41°F occurs in spring and autumn as determined by the Provincial Ministry of Environment Air Studies Branch.

Horticulture — the science and art of growing fruits, vegetables, flowers or ornamental plants.

Infiltration — the process whereby water flows into the ground.

Infiltration Rate — the rate in mm/hr (in/hr) at which water penetrates a soil complex.

Irrigation Season — the season is coincident with the Growing Season dates.

Lag Time — the time between cessation of effluent application and re-entry of people or livestock.

Leaching Requirement — the additional water required to prevent salt accumulation.

Legume — any plant of the family Leguminosae, especially those used for feed, food, or as a soil improving crop.

Live Storage — the difference in reservoir volume between design high water level and maximum drawdown level.

Loam — a combination of sand, silt and clay mineral particles producing a soil textural class intermediate between fine textured (clay) and coarse textured (sandy) soils.

Nutrient — a chemical compound required by plants for growth — in this context generally one containing nitrogen or phosphorus or both.

Occupied Land — land habitually frequented by people or livestock.

Parasites — an organism living in or on another organism from which it obtains its food and causing parasitosis which is an infestation with or a disease caused by parasites.

Pathogen — a specific cause of disease such as bacterium or virus.

PCO — Pollution Control Objectives for Municipal Type waste Discharges in British Columbia.

Pedologist — a scientist that deals with the study of soils.

Permanent Wilting Point — the water content of the soil at which plants growing in it are wilted to the point where they will not recover when placed in the dark for 12 hours in an atmosphere of 100% relative humidity.

Permittee — Holder of a permit to discharge effluent as defined in the Pollution Control Act.

Phreatophyte — water loving plants that grow where their roots can reach into the capillary fringe overlying the water table.

Pisciculture — the science and art of growing fish.

Potential Evapotranspiration — the maximum quantity of water capable of being lost as water vapour, in a given climate, by a continuous stretch of vegetation, covering the whole ground and well supplied with water. (Values available from Engineering and/or Soils Branch of British Columbia Ministry of Agriculture and Food.)

Range — all land producing native forage for animal consumption and lands that are revegetated naturally or artificially to provide a forage cover that is managed like native vegetation — generally considered land that is not cultivated.

Reforestation — renewing of forest cover by seeding or planting.

Salts — that group of substances in which the hydrogen ion of an acid has been replaced by a metallic or metal like ion, in general here the chlorides, nitrates, sulphates, carbonates and bicarbonates of sodium, potassium, calcium, magnesium and ammonium.

Sand — mineral particles less than 2.0 mm and greater than 0.050 mm in diameter.

Silt — mineral particles less than 0.050 mm and greater than 0.0020 mm in diameter.

Silviculture — a phase of forestry dealing with the development and care of forests.

Slow Sand Filters — for purposes of equivalence, as used in the text, a slow sand filter is defined as a filtration bed of sand having an effective size of 0.25 to 0.35 mm, a uniformity coefficient of 2.5 or less, a minimum depth of 762 mm (30 inches) and a design flow rate of 1 cubic metre per square metre (20 gal/ft^2) per day or less.

SS — suspended solids are solids that can be retained on a 0.45 micron filter.

Standard Percolation Rate Test — an empirical field procedure to determine the infiltrative capacity of a soil as described in Bibliography 35 "Manual of Septic Tank Practice".

Symbion — an organism that is one of the partners in symbiosis.

Symbiosis — the living together of two dissimilar organisms in which the association generally is advantageous or even necessary to one or both and is not harmful to either. Such a phenomenon is found among some organisms in biological treatment processes.

Toxic Compound — a poisonous substance that through its chemical action usually kills, injures or impairs an organism.

Transpiration — the emission of water vapor from the surface of plant parts.

Uniformity Coefficient — a coefficient obtained by dividing that particle size of which 60% by weight is smaller, by that size of particle size of which 10% by weight is smaller.

Vacant Land — land occasionally frequented by people or livestock.

Vector — an organism (as an animal, insect) that transmits a pathogen to another organism.

Viruses (pl. of virus) — smallest known infective agents; not visible with light microscopy; no metabolic activity outside host cells; multiply only within host cells.

Zooplankton — microscopic aquatic animal life.

3. DISPOSAL WITHOUT SIGNIFICANT GROUNDWATER RECHARGE

3.1 General

The object of this technique is to use natural processes to effectively recycle the various components of the effluent. Generally the effluent is distributed by the method of spray irrigation. The NUTRIENTS are used by plants and microorganisms and the water lost to atmosphere by EVAPOTRANSPIRATION to the maximum extent possible. Ideally a balance is maintained between the effluent components, soil, climate and crop incorporating the best current agronomic, forestry, health and engineering practice. However, these practices are subservient to the objectives of the Pollution Control Act.

If effluent application in excess of acceptable agricultural rates is a premeditated part of the design it shall be so stated and Section 4.1 on Disposal With Significant Groundwater Recharge also applies.

3.2 Source of Effluent

Municipal type sewage devoid of harmful concentrations of SALTS and TOXIC COMPOUNDS (heavy metals, organic compounds, etc.) will constitute the source of the effluent. Effluents containing toxic substances shall be treated to remove them and/or be upgraded to typical municipal sewage before they qualify as a source. These guidelines do not include the disposal of sludge for which a separate guideline is in preparation.

3.3 Sewage Treatment and Effluent Storage

In conjunction with the Ministry of Health Table 1 has been constructed to safeguard people, crop and cattle from the disease risks inherent in spray irrigating treated municipal effluent. In particular the process requirements in Table 1 were calculated to reduce the BACTERIA and VIRUS content of spray aerosols below a level of risk acceptable to the Ministry of Health and prevent perpetuating the life cycle of PARASITES. In achieving this low level risk it was agreed that buffer zones are no longer required under these conditions which results in a great saving in irrigable land area already in short supply in British Columbia. See also 3.3.7. where storage retention time is reduced below 60 days.

TABLE 1

SEWAGE TREATMENT AND STORAGE REQUIREMENTS FOR DISPOSAL BY SPRAY IRRIGATION FOR ZERO BUFFER ZONE

End Use / Sequence		Forage Production	Livestock Grazing		Forests SILVICULTURE and RANGE		Recreation	HORTICULTURE (2)
			Meat Production	Milk Production				
Effluent Quality Prior to Retention in Storage (1)	BOD_5 mg/L	45	45	45	130	45	20	45
	SS mg/L	60	60	60	130	60	30	60
Minimum Retention Storage Time In Days Prior to Spraying (4)		60	60	60	90	60(6)	60	60
Disinfect After Storage 1 mg/L total Cl residual after 60 minutes contact time.		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Minimum Lag Time Between End of Spray Application and Use in Days (5)		3	3	6	0	0	0(3)	3

NOTES TO TABLE 1

1. *ALGAE and ZOOPLANKTON entering the storage basin from a suitable long term (minimum 60 days) lagoon treatment system may be excluded from the qualitative determination of BOD_5 and SS characteristics.*
2. *Tree and Shrub nursery only. Other horticultural uses will be considered on a site specific basis.*
3. *Spraying only allowed when facilities closed to the public, i.e. at night or on non-operating days.*
4. *This means that at the end of the spray irrigation season the storage lagoon must still contain a 60 day supply of effluent to ensure that no effluent is sprayed that has not been in storage a minimum of 60 days.*
5. *Minimum lag time between the end of spray application and use of the crop is not required for public health reasons when all other requirements for zero buffer zones are provided.*
6. *Mandatory unless relaxed or reduced by the express written permission of the Ministry of Health.*

TABLE 2

SEWAGE TREATMENT REQUIREMENTS FOR DISPOSAL BY RIDGE & FURROW, FLOOD, TRICKLE OR DRIP

Sequence	Requirement	
Effluent Quality for uses listed. (1)	BOD_5 mg/L	45
	SS mg/L	60
Disinfect to 1 mg/L total Cl residual after 60 minutes contact time		
Minimum Time Lag Between End of Application and Use in Days	Forage Production	3
	Grazing Meat Production	3
	Grazing Dairy Production	6
	Forest-Silviculture	0
	Horticulture (2)	0

NOTES TO TABLE 2

1. *Algae and Zooplankton from a suitable long term (minimum 60 days) lagoon treatment system may be excluded from the qualitative determination of BOD_5 and SS characteristics.*
2. *Tree and shrub nursery only. Other horticultural uses will be considered on a site specific basis.*

3.3.1
Apart from health aspects the storage of treated effluent is also required for reasons in PCO 5.6.2.

3.3.2
In a fill and draw reservoir the influent shall be discharged below low water operating level to minimize the quantity of suspended sediments.

3.3.3
To achieve maximum disinfection efficiency effluent shall be withdrawn remote from the area where influent solids are settling.

3.3.4
To achieve uniformity of retention time in storage short circuiting between the influent and effluent shall be precluded.

3.3.5
Storage basin sites shall be examined geotechnically and then designed and constructed to minimize fluid leakage. Leakage shall not aggravate or produce soil or bedrock instability or erosion elsewhere or contaminate ground or surface water.

If INFILTRATION from storage is a deliberate component of the design it must be so stated and Section 4.1 and appropriate sections of 4.2 herein, as circumstances require, will apply for that portion of the discharge.

3.3.6
Storage basins and related appurtenances will be designed and constructed with due cognizance of all the risks and hazards associated with such structures.

3.3.7
Except for recreational use of effluent where storage of treated effluent is not provided as required in Table 1 then buffer zones are required as follows. For each 30 day reduction or portion thereof in the required storage retention time:

(i) 100 m (328 feet) for spray irrigation sites next to residential, commercial or industrial areas;
(ii) 30 m (98 feet) for spray irrigation sites next to arterial roads;
(iii) 15 m (50 feet) for spray irrigation sites next to country roads.

3.3.8
Due to areal distortion of liquid application spraying shall cease in wind velocities greater than 20 km/h (12 m.p.h.) except in case of grass or forest fire.

3.4 Examination of Ground to be Sprayed

3.4.1 Ground Assessment

On site assessments of the area to be irrigated must be carried out by a qualified PEDOLOGIST, Professional AGROLOGIST, Engineer or Geologist, using best current climate and soils data to substantiate that the land is capable of accepting the quantity and quality of the effluent to be discharged within the guidelines hereinafter set forth. This assessment shall describe potential soil and water problems that may be caused or aggravated by irrigation and propose remedial procedures.

3.4.2 Non-agricultural Applications

Agricultural irrigation practices and designs are not necessarily applicable to non-agricultural situations, e.g., forest environments. Persons qualified in forest management, AFFORESTATION, REFORESTATION and forest pedology, should also help provide the assessment required in 3.4.1.

3.4.3 Land Requirements Based on Average Seasonal Irrigation Requirements

The amount of land required for an effluent disposal system cannot be based on the continuous operation of an agricultural irrigation system which normally has the capacity to supply the peak EVAPOTRANSPIRATION demands of a crop, as there are periods in the GROWING SEASON when crop water use is substantially below peak demands. The information in Appendix 1 outlines a method for approximating the amount of land required to handle present and projected effluent volumes by using average seasonal irrigation requirements. Factors such as soils, crops, leaching requirements and irrigation system application efficiencies are taken into account.

3.5 Irrigation Design

3.5.1 General

Section 3.4.3 and Appendix 1 are used to approximate the land required. The "Irrigation Design Manual for Farm Systems in British Columbia" Bibliography #17 should be used to design the mechanical aspects of an actual irrigation system. The design shall take into account crop, soil and climatic characteristics relative to activating a water and nutrient balance that will not detrimentally affect the natural soil structure or other soil properties, surface or ground water. The best use of current agronomic, forestry and engineering practices must be incorporated to optimize the soil/plant SYMBIONS for very extended periods of time. Some general considerations follow.

3.5.1.1 Rooting Depths of Plants Relative to Irrigation

In general, plants derive most of their water requirements from the upper portions of the root zones. For most plants, the effective root depth is less than the maximum depth of root development. EFFECTIVE ROOTING DEPTH is further dependent on soil types, subsoil formations, water table limitations, cultural practices and soil fertility.

3.5.1.2 Soil Texture

Soil texture has important influences on the selection of crops, choice of practices, planning of distribution system, and methods of applying water. In addition texture largely governs the water holding capacity and infiltration rate of the soil. Consequently, soils to be irrigated require thorough investigation and attention in developing irrigation plans. The texture of a soil is determined by the proportions and gradations of the three size groups of mineral grains, namely, SAND, SILT and CLAY.

3.5.1.3 Available Water Storage Capacity of Soils

Forms of soil moisture are generally classified as hygroscopic water, gravity water and capillary water. Hygroscopic water is taken into the soil mineral particles or attached as thin films to their surfaces. It is not available to plants. Gravity water is that which percolates downward due to the force of gravity, largely through noncapillary pore spaces. Capillary water is held in the small pores by capillary forces and is the principal source of water used by plants. Soil water available for plant growth is the amount of water stored between FIELD CAPACITY, and the PERMANENT WILTING POINT. This is referred to as the AVAILABLE WATER STORAGE CAPACITY (AWSC) of the soil.

3.5.1.4 Moisture Availability Coefficient

Water is not equally available to plants over the available water storage capacity range. Additionally crops differ in their ability to remove water from soil, hence, different crops have different AVAILABILITY COEFFICIENTS. For crops which may be irrigated with treated municipal effluent an availability coefficient of 50% is reasonable; however, a different availability coefficient may be used if more specific soil moisture tension information is available.

3.5.1.5 Design Application Rates

Water INFILTRATION RATES are materially affected by soil texture yet soils of the same textural class may have greatly different infiltration properties. Ground slope also affects the infiltration rate and careful consideration must be given to this fact. Maximum application rates are reduced according to the data in Table 3 by multiplying them by the slope coefficient to obtain the maximum allowable rate. The maximum ground slope shall not exceed 20% (PCO 5.6.2.(d)).

TABLE 3
SLOPE COEFFICIENTS

Slope (%)	Slope Coefficient
0 - 5	1.0
6 - 8	0.8
9 - 12	0.6
13 - 20	0.4

3.5.1.6 Evapotranspiration Rates

In the design of an irrigation system, the determination of the maximum daily water use for the area, the soil and the crop that is to be irrigated is of prime importance to achieve best current agronomic/forestry practices. Values of peak evapotranspiration rates for various

locations and available water storage capacities of soils can be found in the "Irrigation Design Manual for Farm Systems in British Columbia" (Bibliography #17).

3.5.1.7 Application Efficiency

The application efficiency of a spray irrigation system will depend on such factors as the selection of the sprinkler, its operating pressure, wind conditions, temperature, and the spacing of the sprinklers. An application efficiency of 72% shall be the design minimum for conventional low volume sprinklers (under 160 L/min. (42gpm)). Refer to "Irrigation Design Manual for Farm Systems in British Columbia", Bibliography #17, for more up to date information as it becomes available on other sprinklers.

TABLE 4
AGRICULTURAL CROPS SUITABLE FOR EFFLUENT DISPOSAL SCHEMES

Shallow Rooted Crops 0.45 m (1½ ft.)	Medium Deep Rooted Crops 0.90 m (3 ft.)	Deep Rooted Crops 1.20 m (plus 4 ft.)
Ladino Clover Pasture Species	Cereals Red Clover	Alfalfa Field Corn

3.5.1.8 Crop Selection

Presently those agricultural crops listed in Table 4 are acceptable for irrigation with treated effluent. With the concurrence of the Ministry of Agriculture and Food and on the basis of the "Health Aspects of Sewage Effluent Irrigation" (Bibliography #23) other crops will be considered.

3.5.2 Spray Irrigation

The five types of sprinkler systems commonly used for effluent spray irrigation are:

a) Wheelmove system
b) Travelling Gun system
c) Handmove system
d) Solid Set system
e) Center Pivot system

The selection of any system will depend on the degree of automation required and the topography. The last two systems have the capability of being fully automated.

3.5.3 Ridge and Furrow, Flood, Trickle or Drip Systems

These systems require detailed designing. Professional engineers, agrologists or designers qualified in these fields must be consulted to design and implement such systems. See Table 2 for effluent quality requirements and crop selection as in 3.5.1.8

3.6 Surface Irrigation Practices

All irrigation systems should be furnished with a complete irrigation plan that shows all design data, operation and maintenance instructions. Detailed information should be supplied for the various crops to be grown to attain best current agronomic practices. (See "Irrigation Design Manual for Farm Systems in B.C.", Bibliography #17.)

3.6.1 Scheduling

A complete irrigation plan as stated in 3.7 shows the interval to be used for irrigation during peak demand periods; however, management may wish to write up a work schedule to suit its operation. Because soil, crop and climatic conditions vary across a plot during a certain time period, it is almost impossible to determine the precise moisture use rates of crops. The operator must know how to examine the soils by using soil moisture instruments or alternately what is called the "hand feel" method to determine soil moisture levels. This will then enable the operator to schedule the irrigation cycles during the season and maintain adequate soil moisture levels for good crop production.

However, operation of the storage and irrigation facilities in any given year should be scheduled in such a way to ensure that the entire LIVE STORAGE of the reservoir will be available at the end of the growing season for the subsequent winter flows.

3.6.2 Crops

Attention must be given to choosing the most suitable crop for the climatic and soil conditions. Harvesting of the crops should be based on best current agricultural practices and suitable storage should be provided for crops. Systematic renewal of stands in a well-planned crop rotation is essential to maintain high productivity.

3.6.3 Equipment Maintenance

All operation and maintenance instructions for engines, electric motors and pumps must be followed. Pump screens must be checked and cleaned daily, more frequently if required. Sprinklers should be patrolled at frequent intervals to check for faulty operation and worn sprinklers, and to ensure that vegetation does not interfere with the normal operation of the sprinklers. At the same time, the fields should be checked for system leaks, ponding or excess runoff. Maintaining the pumping stations in clean, good repair is essential. At all times

an adequate stock of spare parts for pumps, pipes, valves and sprinklers shall be available.

The whole distribution system should be winterized before shutting down for the season. All necessary overhauls should be performed during the off-season.

3.7 EVAPORATION/Spreading Basins/Marshes

3.7.1

Evaporation shall constitute the major portion of the water loss. Water losses by infiltration shall be minimized. Such infiltration shall be calculated and such losses shall satisfy Sections 4.1, 4.2.7, 4.2.8 and 4.2.9. Effluent in excess of evaporation losses traversing a long labyrinth within the basin or a bog or swampland over an extended period of time may be discharged elsewhere if it can be demonstrated that the effluent has been satisfactorily renovated for the discharge method proposed/available.

3.7.2

Effluent quality entering the basin shall not exceed BOD_5-130 mg/L,SS-130 mg/L and shall not be disinfected. Algae or zooplankton entering the basin from long term (min. 30 days) lagoon treatment system may be excluded from the qualitative determination of BOD_5 and SS characteristics.

3.7.3

For design purposes estimated evaporation losses shall be reduced by precipitation amounts falling on the basin and its watershed using best current climatology data and practice.

3.7.4

Whenever possible the basin should be located in such a manner as to ensure maximum exposure to solar radiation and the prevailing winds.

3.7.5

Embankment protection from wave erosion shall be provided according to local wind conditions and length of wind fetch.

3.7.6

To prevent EUTROPHICATION and associated aesthetic nuisances it may be necessary to:

a) precipitate nutrients (e.g. lime, alum, etc.)
b) use algaecides to control plant life (e.g. copper sulphate, etc.) or conversely
c) utilize nutrients by systematic AQUACULTURE (e.g. marshes). Crops so produced may not enter the food chain except by way of green manures or compost to agricultural land.

4. DISPOSAL WITH SIGNIFICANT GROUNDWATER RECHARGE

4.1 General

These disposal methods include high rate irrigation, infiltration basins, subsurface pipe disposal fields which recharge the groundwater (normally with a nutrient component) such that initial effluent quality together with renovation that is achieved by passage through the plant-microbe-soil-rock complex will ensure that the groundwater quality is not adversely affected. Sections 5.2, 5.5 and 5.6.1 and 5.6.3 and Tables 5.2 and 5.4 of the PCO should be consulted. A study by a hydrogeologist will likely be required. Distribution of the effluent over the area to be infiltrated may include spraying and Table 1 applies for zero buffer zones or Section 3.3.7 for storage less than 60 days, but the use of such apparatus does not in itself change the environmental consequences or qualify the scheme as an irrigation one if the majority of the applied water is intended for groundwater recharge.

4.2 Infiltration Basins

4.2.1
Each of two basins shall be capable of disposing of the total discharge for one month under conditions of average precipitation and expected minimum liquid viscosity. A reserve standby area shall be provided for an additional basin of similar capacity. STANDARD PERCOLATION RATE TESTS alone are not suitable as a basis for design since they only indicate what rate the soil will accept water at the test point but are of no value in determining where it will go once in the ground.

4.2.2
Effluent quality shall be determined on the basis of 4.1 above and shall at least conform to Table 5-4 of PCO which are BOD_5-130 mg/L, SS-130 mg/L. To encourage continued biological activity in the basin disinfection is not permitted.

4.2.3
A sludge withdrawal facility and a sludge withdrawal schedule are required on all sewage treatment processes except lagoon systems to prevent excess solids overflowing with possible clogging of the infiltration medium and the natural soil surface.

4.2.4
Where it is not possible to keep an infiltration basin flooded continuously each effluent dose shall utilize the entire area of the infiltration basin in use by pumping sufficient volume to cover the whole bottom on each dose. Dosing siphons may be used in place of pumps where there is daily maintenance and inspection of such devices by competent personnel. For frigid climatic conditions it may be required to construct roofs to prevent freezing of the infiltration surface or to utilize a smaller basin or to store effluent until temperatures are more suitable for infiltration or to keep them flooded with water between dosing if necessary.

4.2.5
The basins shall be designed and constructed so that they can be readily cleaned of accumulated sludge or other debris (e.g. wind blown).

4.2.6
It shall be demonstrated that water infiltrating from such basins will not cause or aggravate soil or bedrock instability or erosion elsewhere (PCO Sec. 5.5(b)).

4.2.7
Infiltration basins shall have a minimum horizontal separation from surface waters through soil of 30.5 m (100 feet) for natural soil horizontal permeabilities of 0.1 cm/sec or less. Separation shall be proportionally greater for increasing permeability coefficients. Consult Table 5-1 (PCO) for quality requirements in the event that the discharge could be considered as one to surface water.

4.2.8
Infiltration basins shall not be located within:

(i) 15 m (50 feet) of a parcel boundary;

(ii) 91.5 m (300 feet) or the groundwater mound effect of the basin, whichever is greater, of any water well or house;

(iii) 305 m (1,000 feet) of a water well drawing from an aquifer affected by the basin located within the zone of lower groundwater potential and where it is also substantiated that the nitrate-nitrogen levels will remain at acceptable levels in the well water. Lesser separation distances may be allowed where it is demonstrated conditions so warrant.

4.2.9
Design and operation shall preclude effluent surfacing within 152 m (500 feet) of the disposal field perimeter in vacant land owned by the discharger and not at all in occupied land or land owned by others (PCO Sec. 5.5(b)).

4.2.10
Infiltration of effluent directly into bedrock fractures or fissures shall be precluded by a depth of soil capable of preventing the passage of bacteria, viruses and parasites into them.

4.2.11
It must be demonstrated that chemical compounds added deliberately to septic tank treatment systems with the intention of improving their performance do not hinder the natural biological action in an anaerobic environment, reduce the settleability of solids in the effluent or disperse them or the floatables throughout the effluent.

4.3 Subsurface Pipe Disposal Fields

4.3.1
To encourage continued biological activity in the disposal field disinfection of effluent is not permitted. Scum, grease and solids shall not gain access to the pipe distribution system in quantities that will clog the granular backfill or natural soil surfaces.

4.3.2
Required size and number of disposal fields is contained in Table 5-4 and its Appendix in the PCO. It is unlikely that Standard Percolation Rate Tests alone will be considered as a suitable basis for design since they only indicate what rate the soil will accept water at the test point but are of no value in determining where it will go once in the ground. The elevation to which the water table will be raised by the discharge will not under any condition be nearer than 1 metre (3.3. feet) to the pipe invert (PCO Sec. 5.5(a)).

4.3.3
Each effluent dose shall utilize the entire capacity of the field being dosed uniformly by pumping to 75% to 100% of the pipe volume on each dose. Dosing siphons may be used in place of pumps where there is adequate inspection and maintenance of such devices by competent personnel. Each of two equal fields shall be dosed on alternate months except in sub-freezing weather when they may be dosed on a schedule that prevents them from freezing.

Pressurized distribution systems will also be considered.

4.3.4
Disposal pipe shall consist of suitably perforated or slotted corrosion resistant continuous straight pipe in lengths not less than 1.8 m (6 feet) or 75 mm (3 inches) in diameter. Pipes connecting septic tanks to dosing apparatus or pipe disposal runs shall be water tight.

4.3.5
Disposal pipes and trench bottoms shall be parallel and at a slope not exceeding one in two hundred. The natural soil surface in "built-up" (above grade) or non-trench systems must be trimmed to a slope not exceeding one in two hundred before placement of backfill.

4.3.6
Perforated distribution pipe runs shall not exceed 30.5 m (100 feet) in length and the end of the pipe shall be suitably plugged or vented to atmosphere.

4.3.7
Granular trench backfill shall be at least 40 cm (1.5 feet) deep below the pipe invert, and 50 mm (2 inches) over the top of the pipe and placed between the pipe and the trench wall. Trench width can be as narrow as is consistent with proper backfill placement but not less than 30 cm (12 inches). Pipe crown shall not be more than 30 cm (12 inches) below final grade.

4.3.8
Granular backfill shall consist of well-graded inert mineral particles all passing a 12.7 mm (½ inch) U.S. Standard Sieve and all retained on a #8 (2.38 mm) U.S. Standard Sieve.

4.3.9
Design and operation shall preclude effluent surfacing within 152 m (500 feet) of the disposal field perimeter in vacant land owned by the discharger and not at all in occupied land or land owned by others (PCO Sec. 5.5(b)).

4.3.10
Disposal fields shall have a minimum horizontal separation from surface waters through soil of 30.5 m (100 feet) for natural soil horizontal permeabilities of 0.1 cm/sec or less. Separation shall be proportionally greater for increasing permeability coefficients. Consult Table 5-1 (PCO) for quality requirements in the event that the discharge could be considered as one to surface water.

4.3.11
Disposal fields shall not be located within:

(i) 6 m (20 feet) of a parcel boundary;
(ii) 30 m (100 feet) or the groundwater mound effect, whichever is greater, of any house;
(iii) 91.5 m (300 feet) or the groundwater mound effect, whichever is greater, of any water well;
(iv) 305 m (1,000 feet) of a water well drawing from an aquifer affected by the field which is located within the zone of lower groundwater potential, and where it is also substantiated that nitrate-nitrogen levels will remain at acceptable levels in the well water. Lesser separation distances in (iii) and (iv) may be allowed where it is demonstrated conditions so warrant.

4.3.12
Infiltration of effluent directly into bedrock fractures or fissues shall be precluded by a depth of soil capable of preventing the passage of bacteria, viruses and parasites into them.

4.3.13
Place observation and monitoring ports at the extremi-

ties of the disposal pipe layout to provide a clear view of the end of the disposal pipe and to the bottom of the backfill.

4.3.14
Observation ports may also be used as ventilation ports to the disposal pipes and backfill.

4.3.15
To assist in maintaining an aerobic atmosphere within the pipe layout and the interstices in the granular backfill provide one ventilation port of the same diameter as, and connected to, the distribution pipe for every 152 m (500 feet) of pipe, with a minimum of four, arranged to promote uniform air circulation throughout the field except during periods of sub-freezing temperature when they should be closed.

4.3.16
Encourage evapotranspiration by the planting and cultivation of suitable grasses, LEGUMES and/or trees (PHREATOPHYTES in particular). Disposal fields shall not be; used for animal enclosures, hard surfaced, built upon or used by any type of vehicle or trailer. (PCO Sec. 5.6.3.(b)).

4.3.17
During sub-freezing/near freezing weather disposal fields shall not be trampled or cleared of snow or other insulating materials (e.g. natural vegetation) or entered except for routine inspection and maintenance by the authorized staff. Septic tanks shall have a suitable depth of soil cover for insulation consistent with local frost penetration.

4.3.18
Disposal fields may be required to be fenced to prevent livestock access and discourage trespass.

4.3.19
The disposal field is considered to have failed when an effluent dose is visible in the pipe invert at any observation port 10 seconds after dosing ceases.

4.3.20
It shall be demonstrated that water infiltrating from such facilities will not cause or aggravate soil or bedrock instability or erosion elsewhere (PCO Sec. 5.5(b)).

4.3.21
A sludge withdrawal facility and a sludge withdrawal schedule are required on all sewage treatment processes except lagoon systems to prevent excess solids overflowing with possible clogging of the pipe distribution system, granular backfill and natural soil face.

4.3.22
It must be demonstrated that chemical compounds added deliberately to septic tank treatment systems with the intention of improving their performance do not hinder the natural biological action in an anaerobic environment, reduce the settleability of solids in the effluent or disperse them or the floatables throughout the effluent.

4.4 Other Methods

4.4.1 Deep Well Injection
Deep well injection of treated effluent constitutes the charging of a deeply buried stratum of unconsolidated sediment or bedrock. It must be demonstrated whether the recharge will eventually surface or be perpetually confined and whether the formation is used as a source of water. Hydrogeological investigations prepared by persons professionally qualified in the field will be required. Before proceeding along these lines it is suggested that "Subsurface Disposal of Waste in Canada" (Bibliography #31) be consulted. It would seem that geological conditions conducive to this type of disposal are rare in British Columbia. Other considerations may eliminate those proposals that are hydrogeologically feasible.

5. MANAGEMENT

5.1 General

As a general rule the larger, more comprehensive or more complicated a land disposal system is the better qualified the management will have to be. The best conceived design can be ruined by poor management. The consequences of mistakes in the operation of land disposal schemes can be at least as noxious and pervasive as those relating to surface water discharges.

5.2 Managers

5.2.1 Irrigation Systems

Persons responsible for the management of irrigation works should be technically qualified in soil/plant science, the irrigation techniques being used and the other agronomic practices needed to successfully operate the system in the interest of pollution prevention and abatement.

5.2.2 Other Surface/Subsurface Disposal Methods

Generally managers will also be charged with the operation of the sewage treatment plant and the final disposal of the treated effluent. In such cases they shall be required to be qualified in all phases of both aspects of the scheme.

5.2.3 Effluent/Cropping/Grazing Contracts

It is the PERMITTEE'S responsibility to prevent pollution and health hazards. Contracting the disposal of effluent or harvesting of resultant crops will not relieve the permittee of any responsibility and will only be considered where the contracting party is suitably qualified.

6. MONITORING

6.1 General

Monitoring schedules are required to be carried out to ensure that the operation is not causing pollution, to anticipate degradation of the soil-water-plant regime and in general to provide a continuous accounting of all the various elements in and out of the system to see if they are maintaining an acceptable balance.

6.2 Schedules

Schedules shall be provided for monitoring the following topics by the permittee for approval. The emphasis may vary depending upon the method of effluent application.

6.2.1 Effluent Quantity and Quality

Install a suitable flow measuring device to record daily the discharge for a 24-hour period into the treatment works. In general the effluent should be monitored for BOD_5 and SS in all cases before application to land or discharge to storage. To ascertain the input side of the nutrient budget monitor the effluent being spray irrigated for total nitrogen and phosphorus.

6.2.2 Agricultural/Forest Soils

Condition and composition of the soil is to be determined before irrigation begins and assessed regularly thereafter for the following items:

Salinity
Sodium absorption ratio
pH
Cation exchange capacity
Nitrogen (total)
Phosphorus
Potassium
Magnesium
Calcium

6.2.3 Crop

The crop shall be measured for yield, and Phosphorus and Nitrogen uptake to provide part of the output side of the nutrient balance budget.

6.2.4 Effluent Application

6.2.4.1
A daily log shall be kept of the amount and location of effluent applied to land in irrigation schemes. This information shall be organized to provide:

(i) comparison with the scheduled application;
(ii) the total application accumulation on any site to date in millimetres (inches);
(iii) a determination of available reservoir storage on that date in cubic metres (gallons).

6.2.4.2
A daily record shall be kept of the disposal field or infiltration basin used each day and the amount in cubic metres (gallons) discharged to it.

6.2.5 Climate

When any method of surface irrigation is practised daily records may be required to be kept of solar radiation, wind velocity and direction, temperature, humidity, precipitation and evapotranspiration. Such measurements will be taken at the irrigation site where they will not be affected by any irrigation in progress.

6.2.6 Groundwater Monitoring

The general purpose of a monitoring program shall be to determine both short and long-term changes in groundwater quality and movement that occur due to the application of effluent to land.

6.2.6.1
In situations where an unconfined aquifer exists within 15 m (50 feet) of ground surface below any land-disposal plot, or where the application of effluent itself causes a water table to be formed within the same vertical distance, institute an acceptable groundwater monitoring program. It may be necessary to monitor deeper aquifers where the soil profile consists of coarse highly permeable materials.

6.2.6.2
The number of sampling wells required and their distance separation from the disposal area will depend to a large extent on both the surface topography and the topography of the impermeable boundary of the unconfined aquifer, but in general shall be as follows:

Irrigation — in zone of lower groundwater potential two wells per 40 hectares (100 acres) area, plus a minimum of two background wells located upstream of the irrigation site(s).

Infiltration basins — in zone of lower groundwater potential one well per 2,270 cubic metres/day (.5 Mgd) of design capacity plus a minimum of two background wells.

Vertical shallow well or horizontal pipe disposal — in zone of lower groundwater potential one well for every 455 cubic metres (10,000 gallons) per day of design capacity or part thereof, plus at least one background well.

Evaporation-spreading basin — in the zone of lower groundwater potential one well and one background well.

6.2.6.3

Except for irrigation systems the frequency of sampling and analysis shall be monthly during the first year of operation of the disposal system, and quarterly thereafter. Frequency of sampling and analysis in the case of irrigation systems will be considered individually.

Parameters to be monitored shall generally include the following:

- Total COLIFORMS
- Total Phosphorus
- Nitrite Plus Nitrate Nitrogen
- Conductivity
- pH
- FECAL Coliforms
- Total Kjeldahl Nitrogen
- Occasional full chemical analysis of the main cations and anions

In certain cases, other quality characteristics may be required to be measured at the discretion of the Director.

6.2.7 Surface Water Monitoring

In general it is intended that surface water monitoring will be carried out by the Waste Management Branch. Where local conditions warrant, it may be necessary to gather specific quality information on nearby surface waters. The details of such monitoring requirements should be considered on an individual basis.

6.2.8 Analyses

Analyses are to be carried out in accordance with procedures described in the second edition (February, 1976) of "A Laboratory Manual for the Chemical Analysis of Waters, Wastewaters, Sediments and Biological Materials", and/or by suitable alternative procedures as approved by the Director.

Copies of the above-mentioned manual are available from the Environmental Laboratory, 3650 Wesbrook Crescent, Vancouver, British Columbia, V6S 2L2, at a cost of $10.00, and are also available for inspection at all Waste Management Branch offices.

7. RECORDS AND REPORTING

7.1

All agronomic, forestry, engineering, health monitoring information, measurements and observations shall be kept up-to-date, suitably tabulated, and available for inspection.

7.2

Together with the raw data shall be a written report analysing the data and assessing the performance of the system. Where required, recommendations will be made to improve or adjust the operation in the light of implications of the accumulating data of the current and preceding years.

8. MISCELLANEOUS

8.1 Employees Health

It is the continuing responsibility of the employer to emphasize preventative hygienic practices in the work situation to minimize health hazards. Persons employed should have current vaccinations for typhoid and poliomyelitis.

8.2 Signs

Prominent "NO TRESPASSING" signs shall be displayed at storage lagoons describing the contents thereof and may be necessary for other land disposal sites.

8.3 Fences

Fences suitable to preclude livestock and discourage trespassing may be required for storage lagoons and other disposal methods, appurtenances or facilities.

8.4 Extra-territorial Consequences

There are other routes (VECTORS) by which disease organisms could be disseminated from a ground disposal project such as the ingress/egress of various wild animal species that cannot be controlled like domestic animals. For example:

a) **Bees**
Apart from producing honey, bees also provide the essential pollination service required by various agricultural/horticultural operations. It is reasonable to assume that bees foraging a freshly sprayed field could pick up PATHOGENS/parasites. How or if pathogens/parasites survive the honey making process is not known.

b) **Wild Animals (deer, game birds, etc.)**
Numerous wild animal species are likely to take advantage of the crop produced. They could serve as an intermediate host (vector) for some parasites yet be harvested by man many miles from the site.

c) **Mosquitoes, flies**
Mosquitoes and flies are known vectors for various pathogens. The facilities shall be operated in a manner that discourages their breeding or habitation.

d) **Birds**
Scavengers, in particular seagulls, starlings and crows already represent an unknown health hazard whose risk factor should not be increased by surface disposal methods.

However, it is considered that the treatment and storage parameters proposed herein should effectively reduce these risks below an acceptable minimum and possibly even below those risks already publicly accepted and inherent in the harvesting, processing and marketing of many other agricultural products.

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APPENDIX I

BRITISH COLUMBIA AVERAGE SEASONAL IRRIGATION REQUIREMENTS TO ESTIMATE THE CROP LAND REQUIRED FOR A MUNICIPAL EFFLUENT SPRAY IRRIGATION SYSTEM

1. Introduction

The objective, when designing irrigation systems for land disposal of sewage effluent, is to maximize water application without causing environmental deterioration. Consideration of the hydrological cycle demonstrates that applications of effluent in excess of the average soil moisture deficit must, in the long term, either run off or drain out of the soil profile into the groundwater. The average irrigation requirement can be considered to be equivalent to the average soil moisture deficit. An analysis of the average seasonal irrigation requirement has been calculated by the Air Management Branch, British Columbia Ministry of Environment for 78 locations in British Columbia. The values presented in the attached tables are calculated based on empirical relationships developed from average seasonal irrigation requirements reported by Coligado, Baier and Sly in the Agriculture Canada series of bulletins entitled "Risk Analysis of Weekly Climatic Data for Agricultural and Irrigation Planning" (Bibliography #51). These values, adjusted for leaching requirement and application efficiency, should be used for determining the crop land area required for sewage effluent spray irrigation systems. Procedures for calculating and applying leaching requirement and application efficiency are outlined in Sections 3 and 4 of this Appendix.

Once the land area required has been determined, the designer should refer to the "Irrigation Design Manual for Farm Systems in British Columbia" (Bibliography #17) for peak evapotranspiration figures on a daily basis to design a system.

2. Using the Average Seasonal Irrigation Tables

To use the tables to determine the average seasonal irrigation requirement, the available water storage capacity of the soil must be determined. The available water storage capacity (AWSC) of the soil is the amount of water stored between field capacity and the permanent wilting point. The capacity of a soil to store water depends on the soil texture and structure. To obtain approximations of the AWSC of a soil it is necessary to determine the texture of the soil for the effective rooting depth of the crop to be irrigated. Table 5 provides a guide to AWSC for British Columbia soils.

Soil texture can be determined from soil survey maps and reports, or by submitting samples to the Soils Branch, British Columbia Ministry of Agriculture and Food, 1873 South Spall Road, Kelowna, British Columbia, V1Y 4R2. To calculate the AWSC of the soil profile it is necessary to multiply the value from Table 5 by the crop rooting depth given in Table 6.

Table 5 — Guide to AWSC for B.C. Soils

Soil Texture	AWSC	
	mm/m	in./ft.
Sand	85	1.0
Loamy Sand	100	1.2
Sandy Loam	125	1.5
Fine Sandy Loam	140	1.7
Loam	175	2.1
Silt Loam	210	2.5
Clay Loam	200	2.4
Clay	200	2.4

(from British Columbia Irrigation Guide)

Table 6 — Effective Rooting Depths for Various Crops
(Providing soil conditions and water table depths do not limit rooting depth)

Shallow 0.45 m (1½ ft.)	Medium Deep 0.90 m (3 ft.)	Deep 1.20 m (4 ft.)
Ladino Clover Pasture Species	Cereals Red Clover	Alfalfa Field Corn

(from "Irrigation Design Manual for Farm Systems in British Columbia" Bibliography #17).

For example, for an alfalfa crop rooting to a depth of 1.20 m on a loam soil,

AWSC = 1.2 m x 175 mm/m = 210 mm
(AWSC = 4 ft. x 2.1 in./ft. = 8.4 in.)

This AWSC value would be used to determine the average seasonal irrigation requirement (IR) from the irrigation requirement tables for any particular location. (Note — the irrigation requirement calculations assume an availability coefficient of 50%). For example, if this alfalfa crop were grown in the Kamloops area, then from the attached Table 7 under the 200 mm (8 in.) column the IR = 379 mm (14.9 in.)

3. Calculation of the Leaching Requirement

In order to prevent salt accumulation in the soil it is necessary in the design of an irrigation system to allow a net leaching of water through the soil profile. The seasonal LEACHING REQUIREMENT can be approximated using the technique outlined in the Food and Agriculture Organization of the United Nations publication "Guide for Predicting Crop Water Requirements". The leaching requirement (LR) is expressed as a fraction of the irrigation requirement.

$$LR = \frac{EC_{irr}}{4}$$

where EC_{irr} is the electrical conductivity of the irrigation water expressed in mmhos. Data on the electrical conductivity of irrigation waters in British Columbia is available from the Agriculture Canada publication "Suitability for Irrigation of Water from Lakes and Streams in the Southern Interior of British Columbia" (Bibliography #53). Electrical conductivity of sewage effluent would have to be determined by laboratory analysis. Unless the electrical conductivity of the effluent exceeds 1.0 mmhos, an assumed LR = 0.2 is sufficient. Calculation of the irrigation requirement including the need for leaching water (IR_o) is done as follows:

$$IR_o = \frac{IR}{1\text{-}LR}$$

An example of the leaching requirement calculation can be considered using a hypothetical electrical conductivity of the irrigation effluent water EC_{irr} = 0.8 mmhos. Therefore the leaching requirement can be calculated as:

$$LR = \frac{0.8}{4} = 0.2$$

If this effluent was to be used to grow alfalfa on a loam soil in the Kamloops area (see above example) then IR = 379 mm (14.9 in.) and therefore, the irrigation requirement including leaching is calculated.

$$IR_o = \frac{379}{1\text{-}0.2} = 474 \text{ mm (18.6 in.)}$$

4. Application Efficiency

The application efficiency (A.E.) of sprinkler irrigation systems account for the lack of uniformity in water distribution patterns from sprinklers and depends on such factors as the selection of the sprinkler, the sprinkler type, nozzle size and operating pressures, prevalent wind, temperature and humidity conditions. Application efficiency of 72% shall be the design minimum for conventional low volume sprinklers — under 160 L/min (42 gpm). Refer to the "Irrigation Design Manual for Farm Systems in British Columbia" (Bibliography #17) for specific application efficiencies. Calculation of the irrigation requirement including the application efficiency (IR_{Tot}) is done as follows:

$$IR_{Tot} = \frac{IR_o}{A.E.}$$

Continuing the example from above, IR_{Tot} for the alfalfa crop in the Kamloops area with an effluent electrical conductivity of 0.8 mmhos and an irrigation application efficiency of 72% is calculated as:

$$IR_{Tot} = \frac{474}{0.72} = 658 \text{ mm (25.8 in.)}$$

Table 7

AVERAGE SEASONAL IRRIGATION REQUIREMENTS IN BRITISH COLUMBIA

Location	Irrigation Requirement (IR) For AWSC of					
	25 mm (1 in.)	50 mm (2 in.)	100 mm (4 in.)	150 mm (6 in.)	200 mm (8 in.)	250 mm (10 in.)
Abbotsford	206 mm (8.1 in.)	174 mm (6.9 in.)	123 mm (4.8 in.)	94 mm (3.7 in.)	64 mm (2.5 in.)	41 mm (1.6 in.)
Aberfeldie	247 (9.7)	219 (8.6)	173 (6.8)	145 (5.7)	118 (4.6)	93 (3.7)
Agassiz	195 (7.7)	157 (6.2)	100 (3.9)	69 (2.7)	35 (1.4)	14 (0.6)
Alberni	286 (11.3)	261 (10.3)	219 (8.6)	190 (7.5)	164 (6.5)	139 (5.5)
Alta Lake	208 (8.2)	176 (6.9)	125 (4.9)	95 (3.8)	66 (2.6)	43 (1.7)
Ashcroft	424 (16.7)	407 (16.0)	370 (14.6)	340 (13.4)	314 (12.4)	289 (11.4)
Baldonnel Ft. St. John	246 (9.7)	218 (8.6)	172 (6.8)	144 (5.7)	117 (4.6)	92 (3.6)
Babine Lake	206 (8.1)	173 (6.8)	122 (4.8)	93 (3.7)	63 (2.5)	40 (1.6)
Barkerville	230 (9.1)	201 (7.9)	154 (6.1)	125 (4.9)	98 (3.8)	73 (2.9)
Beatton River	208 (8.2)	175 (6.9)	124 (4.9)	95 (3.8)	66 (2.6)	43 (1.7)
Big Creek	256 (10.1)	229 (9.0)	184 (7.2)	155 (6.1)	129 (5.1)	104 (4.1)
Bralorne	263 (10.4)	237 (9.3)	193 (7.6)	164 (6.5)	138 (5.4)	113 (4.5)
Carmi	238 (9.4)	210 (8.3)	163 (6.4)	135 (5.3)	108 (4.2)	83 (3.3)
Chilliwack	195 (7.7)	160 (6.3)	104 (4.1)	74 (2.9)	42 (1.6)	20 (0.8)
Comox	251 (9.9)	224 (8.8)	178 (7.0)	150 (5.9)	123 (4.9)	98 (3.9)
Cowichan Lake	276 (10.9)	251 (9.9)	207 (8.2)	179 (7.0)	153 (6.0)	127 (5.0)
Cranberry (Valemont)	275 (10.8)	250 (9.8)	207 (8.1)	178 (7.0)	152 (6.0)	127 (5.0)
Cranbrook	350 (13.8)	329 (12.9)	289 (11.4)	260 (10.3)	235 (9.3)	209 (8.2)
Creston	359 (14.1)	338 (13.2)	299 (11.8)	270 (10.6)	245 (9.6)	219 (8.6)
Cumberland	276 (10.9)	251 (9.9)	207 (8.2)	179 (7.0)	153 (6.0)	128 (5.0)
Dease Lake	206 (8.1)	174 (6.8)	122 (4.8)	93 (3.7)	63 (2.5)	40 (1.6)

Table 7 (Cont'd)

AVERAGE SEASONAL IRRIGATION REQUIREMENTS IN BRITISH COLUMBIA

Location	Irrigation Requirement (IR) For AWSC of					
	25 mm (1 in.)	50 mm (2 in.)	100 mm (4 in.)	150 mm (6 in.)	200 mm (8 in.)	250 mm (10 in.)
Dog Creek	233 (9.2)	204 (8.0)	157 (6.2)	128 (5.0)	100 (4.0)	76 (3.0)
Dome Lake	235 (9.2)	206 (8.1)	159 (6.3)	130 (5.1)	103 (4.1)	79 (3.1)
Fauquier	282 (11.1)	257 (10.1)	214 (8.4)	186 (7.3)	160 (6.3)	135 (5.3)
Fernie	233 (9.2)	204 (8.0)	156 (6.2)	128 (5.0)	100 (4.0)	76 (3.0)
Ft. Nelson	205 (8.1)	173 (6.8)	121 (4.8)	92 (3.6)	62 (2.4)	39 (1.5)
Ft. St. James	233 (9.2)	204 (8.0)	157 (6.2)	128 (5.0)	101 (4.0)	76 (3.0)
Germansen Landing	221 (8.7)	190 (7.5)	142 (5.6)	113 (4.4)	85 (3.3)	61 (2.4)
Golden	285 (11.2)	261 (10.3)	218 (8.6)	189 (7.5)	164 (6.4)	138 (5.4)
Hedley	382 (15.0)	362 (14.3)	324 (12.8)	295 (11.6)	269 (10.6)	244 (9.6)
Hope	204 (8.0)	171 (6.7)	120 (4.7)	90 (3.6)	60 (2.4)	37 (1.5)
Horsefly Lake	196 (7.7)	161 (6.3)	106 (4.2)	76 (3.0)	44 (1.7)	22 (0.9)
Hudson Hope	232 (9.1)	203 (8.0)	155 (6.1)	127 (5.0)	99 (3.9)	75 (3.0)
Joe Rich Creek	271 (10.7)	245 (9.7)	201 (7.9)	173 (6.8)	147 (5.8)	122 (4.8)
Kamloops	486 (19.2)	471 (18.6)	436 (17.2)	406 (16.0)	379 (14.9)	354 (13.9)
Kaslo	250 (9.8)	222 (8.8)	177 (7.0)	148 (5.8)	122 (4.8)	97 (3.8)
Kelowna	425 (16.7)	407 (16.0)	370 (14.6)	341 (13.4)	315 (12.4)	289 (11.4)
Keremeos	485 (19.1)	470 (18.5)	434 (17.1)	404 (15.9)	377 (14.9)	352 (13.9)
Kimberly	349 (13.7)	328 (12.9)	289 (11.4)	260 (10.2)	234 (9.2)	209 (8.2)
Kleena Kleene	288 (11.3)	263 (10.4)	221 (8.7)	192 (7.6)	166 (6.6)	141 (5.6)
Lytton	449 (17.7)	433 (17.0)	397 (15.6)	367 (14.4)	341 (13.4)	315 (12.4)
McBride	311 (12.3)	288 (11.3)	247 (9.7)	218 (8.6)	193 (7.6)	167 (6.6)

Table 7 (Cont'd)

AVERAGE SEASONAL IRRIGATION REQUIREMENTS IN BRITISH COLUMBIA

Location	Irrigation Requirement (IR) For AWSC of					
	25 mm (1 in.)	50 mm (2 in.)	100 mm (4 in.)	150 mm (6 in.)	200 mm (8 in.)	250 mm (10 in.)
McCulloch	245 (9.7)	218 (8.6)	172 (6.8)	143 (5.6)	117 (4.6)	92 (3.6)
Merritt	403 (15.9)	384 (15.1)	347 (13.7)	317 (12.5)	292 (11.5)	266 (10.5)
Nanaimo	247 (9.7)	219 (8.6)	174 (6.8)	145 (5.7)	118 (4.7)	94 (3.7)
New Hazelton	217 (8.5)	186 (7.3)	137 (5.4)	108 (4.3)	79 (3.1)	56 (2.2)
Okanagan Centre	385 (15.2)	366 (14.4)	328 (12.9)	299 (11.8)	273 (10.8)	248 (9.8)
Oliver	504 (19.9)	490 (19.3)	455 (17.9)	425 (16.7)	398 (15.7)	373 (14.7)
150 Mile House	257 (10.1)	231 (9.1)	186 (7.3)	157 (6.2)	131 (5.2)	106 (4.2)
Pemberton Meadows	290 (11.4)	265 (10.4)	223 (8.8)	194 (7.6)	169 (6.6)	143 (5.6)
Penticton	452 (17.8)	436 (17.2)	400 (15.7)	370 (14.6)	344 (13.5)	318 (12.5)
Powell River	221 (8.7)	190 (7.5)	142 (5.6)	113 (4.4)	85 (3.3)	61 (2.4)
Prince George	218 (8.6)	188 (7.4)	138 (5.5)	122 (4.4)	84 (3.3)	58 (2.3)
Princeton	398 (15.7)	279 (14.9)	342 (13.5)	312 (12.3)	287 (11.3)	261 (10.3)
Quesnel	231 (9.1)	202 (7.9)	154 (6.1)	126 (4.9)	98 (3.9)	74 (2.9)
Revelstoke	211 (8.3)	180 (7.1)	129 (5.1)	100 (3.9)	71 (2.8)	48 (1.9)
Rossland	289 (11.4)	265 (10.4)	222 (8.8)	194 (7.6)	168 (6.6)	143 (5.6)
Saanichton	274 (10.8)	249 (9.8)	205 (8.1)	177 (7.0)	151 (5.9)	125 (4.9)
Salmon Arm	308 (12.1)	285 (11.2)	243 (9.6)	215 (8.5)	189 (7.5)	164 (6.5)
Saltspring Island	269 (10.6)	243 (9.6)	199 (7.9)	171 (6.7)	145 (5.7)	120 (4.7)
Shawnigan Lake	317 (12.5)	295 (11.6)	254 (10.0)	225 (8.9)	200 (7.9)	174 (6.9)
Sinclair Pass	212 (8.4)	181 (7.1)	131 (5.2)	102 (4.0)	73 (2.9)	49 (1.9)
Smithers	235 (9.3)	206 (8.1)	159 (6.3)	131 (5.1)	103 (4.1)	79 (3.1)

Table 7 (Cont'd)

AVERAGE SEASONAL IRRIGATION REQUIREMENTS IN BRITISH COLUMBIA

Location	Irrigation Requirement (IR) For AWSC of					
	25 mm (1 in.)	50 mm (2 in.)	100 mm (4 in.)	150 mm (6 in.)	200 mm (8 in.)	250 mm (10 in.)
Summerland	423 (16.7)	405 (16.0)	369 (14.5)	339 (13.4)	313 (12.3)	288 (11.3)
Tappen	335 (13.2)	314 (12.3)	273 (10.8)	245 (9.6)	219 (8.6)	194 (7.6)
Tatlayoko Lake	289 (11.4)	265 (10.4)	222 (8.7)	193 (7.6)	168 (6.6)	142 (5.6)
Telkwa	222 (8.7)	192 (7.5)	143 (5.6)	114 (4.5)	86 (3.4)	62 (2.5)
Terrace	199 (7.9)	166 (6.5)	113 (4.4)	83 (3.3)	52 (2.1)	30 (1.2)
Vananda	214 (8.4)	182 (7.2)	133 (5.2)	104 (4.1)	75 (2.9)	51 (2.0)
Vancouver Airport	239 (9.4)	210 (8.3)	164 (6.4)	135 (5.3)	108 (4.3)	83 (3.3)
Vanderhoof	227 (8.9)	197 (7.8)	149 (5.9)	121 (4.8)	93 (3.7)	69 (2.7)
Vavenby	308 (12.1)	284 (11.2)	243 (9.6)	214 (8.4)	189 (7.4)	163 (6.4)
Vernon Coldstream	328 (12.9)	306 (12.1)	266 (10.5)	237 (9.3)	212 (8.3)	186 (7.3)
Victoria	358 (14.1)	338 (13.3)	299 (11.8)	270 (10.6)	244 (9.6)	219 (8.6)
Westwold	381 (15.0)	362 (14.2)	232 (12.7)	294 (11.6)	269 (10.6)	243 (9.6)
White Rock	216 (8.5)	185 (7.3)	136 (5.3)	107 (4.2)	78 (3.1)	55 (2.2)
Williams Lake	208 (8.2)	176 (6.9)	126 (4.9)	96 (3.8)	67 (2.6)	44 (1.7)
Wistaria	226 (8.9)	196 (7.7)	148 (5.8)	120 (4.7)	92 (3.6)	68 (2.7)